MARSBUGS:

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Co-editors:

David Thomas, Life Sciences Department, Belleville Area College, Belleville, IL 62221, USA, thomasd@basenet.net (basegrp.com).

Julian Hiscox, Microbiology Department, BBRB 17, Room 361, University of Alabama at Birmingham, Birmingham, AL 35294-2170, USA, julian_hiscox@micro.microbio.uab.edu.

CONTENTS

MARS PATHFINDER PASSES MAJOR SET OF ENGINEERING MILESTONES
NASA press release

Mars Pathfinder, a NASA Discovery program mission designed to deliver a lander, camera and instrument-laden rover to the Martian surface on July 4, 1997, has successfully completed an initial set of engineering tests intended to validate the spacecraft's unique atmospheric entry, descent and landing techniques.

"Mars Pathfinder will employ a new and innovative approach to placing a lander on the surface of Mars, in keeping with NASA's 'faster, better and cheaper' philosophy of planetary exploration," said Tony Spear, Pathfinder project manager at NASA's Jet Propulsion Laboratory (JPL).

"This series of diverse tests has given us great confidence that the spacecraft will arrive safely and securely on Mars," Spear said. "A truly exciting scientific mission will then be ready to unfold."

The Viking 1 and 2 Mars landers of the mid-1970s used a complex, computer-controlled liquid retrorocket system to achieve a soft landing at about five miles per hour (eight kilometers per hour). In contrast, the smaller, tetrahedral-shaped Pathfinder lander will use a combination of parachutes, solid-fuel rockets and inflatable air bags to perform a safe, relatively hard landing at about 35 miles per hour (56 kilometers per hour).

Recent parachute drop stability tests were performed by Pioneer Aerospace of Windsor, CT, in the desert near Yuma, AZ. These tests successfully demonstrated the parachute configuration that will be used to bring the lander gracefully through the thin Martian atmosphere, said Ann Mauritz, JPL lead subsystem engineer.

Another element of the spacecraft's descent subsystems, the solid rocket motors, were tested at the China Lake Naval Weapons Center in Ridgecrest, CA. These tests involved dropping a simulated lander on a parachute from a helicopter and then firing three small prototype solid rockets to further slow the craft's fall toward the surface.

"The tests went just as predicted," said Dr. Les Compton, JPL lead subsystem engineer, with the simulated lander essentially coming to a dead stop in mid-air while at the same time maintaining a stable orientation with respect to the ground. Full-scale rocket prototypes, recently tested by Thiokol Corporation at Elkton, MD, will be used in full-scale subsystem tests to be carried out at China Lake later this summer.

Pathfinder's landing will be cushioned by four large air bags completely surrounding the lander's exterior petals. The air bag- based soft landing was recently demonstrated by the air bag designers, ILC Dover of Frederica, DE, inside the 120-foot (36.5- meter) vacuum chamber at the NASA Lewis Research Center's Plum Brook Station near Sandusky, OH. The vacuum chamber provides a way to simulate the very thin atmosphere of Mars, and the tests demonstrated the viability of the air bag design in softening the force of the impact on the lander and its delicate payload.

The air bag was dropped from a height of 70 feet (21 meters) onto a 40-foot (12-meter) platform containing many large rocks similar to those found on Mars, according toTom Rivellini, JPL lead subsystem engineer. "The initial full-scale prototype drop tests were very successful," Rivellini said. "Engineers were able to test several air bag fabric construction techniques simultaneously. The tests showed that air bags constructed of a double-layered fabric will be necessary to provide a sufficiently rugged cushioning effect." A second phase of prototype drop testing later this year will demonstrate the durability of the new double-layered air bags, at even higher impact levels.

Like Viking, the Pathfinder lander will arrive at Mars packaged inside a space capsule-shaped entry vehicle. Hitting the thin upper atmosphere of Mars at more than 17,000 miles per hour (27,000 kilometers per hour), the entry vehicle's heat shield will slow the craft to 900 miles per hour (1,450 kilometers per hour) in about two minutes. An onboard computer will sense the slow-down in speed and then deploy a large parachute. The parachute can slow the lander down to about 155 miles per hour (250 kilometers per hour) in the rarified atmosphere of Mars, which is only 1/100th as dense as Earth's.

An onboard radar altimeter inside the lander will monitor the distance to the ground. At about 330 feet (100 meters) above the surface, the computer will inflate the air bags.

Seconds later, three solid rocket motors placed inside the top half of the entry vehicle above the lander will be fired. In approximately two seconds, the rockets will bring the lander to a stop some 40 feet (12 meters) above the Martian ground. The parachute will be released, and the lander, nestled inside its protective air bag cocoon, will fall to the ground, bouncing and rolling until it stops.

Within about an hour, the air bags will be deflated and partially retracted toward the lander. Pathfinder will then open its three metallic petals and stand itself right side up from any side that it happens to be lying on. The microrover, attached to the inside of one of the petals, will be exposed to the Martian terrain for the first time. After the lander camera has taken a photograph of its position on the Martian surface, engineers will instruct the rover to drive off and begin exploring the immediate surroundings, an ancient Martian flood plain known as Ares Vallis.

Scheduled for launch in December 1996, Mars Pathfinder is part of a new generation of low-cost spacecraft with highly focused science goals designed to explore planets and other celestial bodies of the solar system. Discovery missions are capped at $150 million (FY92) each in development costs and must be readied for launch within 36 months.

Mars Pathfinder is managed by the Jet Propulsion Laboratory for NASA's Office of Space Science, Washington, DC.

KEEPING A SATELLITE "EYE" ON ENVIRONMENTAL OFFENDERS
ESA press release

The Exxon Valdez disaster that occured on Good Friday in 1989 off the coast of Alaska is still a nightmare in the memories of many people. The supertanker, about 330 metres long and carrying a cargo of over 200 000 tonnes of crude oil, was holed when it struck a reef. Because of the time it took for the rescue services to arrive on the scene, over 40 000 tonnes of crude oil poured into the Prince William Sound, precipitating an environmental catastrosphe of unimaginable proportions. A stretch of coastline over 1500 kilometres in length was covered by a thick layer of oil and an estimated 400 000 sea birds died from oil pollution, not to mention the effects on marine life -- fish chocked because their gills were glued with oil, light was obscured destroying large expanses of algae and swarms of planktons perished because the oil lying on the sea surface prevented an exchange of gases with the atmosphere.

But the Exxon Valdez accident was not the first of such tanker disasters and by no means the worst to have afflicted the Earth's oceans. Eleven years earlier, in March 1978, the Amoco Cadiz, a Liberian-registered tanker, ran aground off the French port of Brest and broke up. Its entire cargo of 230 000 tonnes of crude oil poured into the sea. In July 1979, two supertankers, the Atlantic Empress and the Aegean Captain collided off the coast of Tobago. The Atlantic Empress was carrying 276 000 tonnes of crude oil and sank two weeks later.

Every supertanker accident generating large-scale pollution makes the headlines. But is is not only spectacular cases such as these that pose a threat to the environment. The numerous small oil slicks that poison the high seas when ships' captains flush out their tanks at dead of night are equally to blame. At the end of the 1980s, the American National Research Council estimated that this practice accounted for a yearly average of over 3 million tonnes of oil in the world's ocean -- enough to fill twenty tankers the size of the Exxon Valdez. Accidents on drilling platforms and leaks in pipelines linking offshore oil rigs with the mainland also give cause for great concern since, in addition to environmental damage, which is hard to estimate, they represent a tangible financial loss.

For as long as pipelines are inspected in only a few, closely delimited and mostly coastal zones, it will be impossible to monitor the seas using conventional means for the purpose of identifying environmental offenders because of the mainly financial but also the meteorological obstacles standing in the way. In any event about 70% of the Earth's surface consists of oceans and it is impossible to provide uninterrupted satellite surveillance of the whole area. Even from space, it is very difficult to identify offenders or detect pipeline leaks using conventional Earth observation methods because in daytime fog, clouds and reflected sunlight greatly hinder the detection of oil slicks and in the dark all cats are grey. Similar limitations prevent swift appraisal of the threat posed by tanker accidents although this is necessary in order to take rescue measures and coordinate them. For some years now, a solution to this dilemma has been available. It lies in the use of satellite radar instruments including those on board the European remote-sensing satellite, ERS-1, which has been circling the Earth since summer 1991. These instruments can detect even quite small oil slicks from space. This is possible because of the "smoothing" effect of oil on waves.

As Professor Olaf M. Johannessen of the Nansen Environmental and Remote-Sensing Centre at Solheimsviken (Norway) explains: "Satellites with active microwave sensors illuminate the scene to be observed and record the amplitude as well as the "phase" of the backscattered radar signal. The return signal depends among other things on the sea surface roughness, which, at a first approximation, is described by short Bragg waves (at centimetre wavelengths). Because oil dampens the Bragg waves, oil spills show up in the radar images as dark areas while the sea around them is bright. However, there are other phenomena that dampen the Bragg waves too, such as thin layers of algae, which produce a similar radar image."

The ERS-1 environmental research satellite, which belongs to the European Space Agency (ESA), is one of the first satellites to be equipped with an active radar system of this type. Using a very special radar antenna, it takes high spatial-resolution "pictures" of the Earth's surface. Since the resolution or acuity of vision of a detector depends primarily on the antenna diameter, the system used is described as the synthetic aperture radar (SAR). It exploits the fact that the satellite moves a little further along its orbit between the time of emission of the radar beam and reception of the return signal. The resulting succession of backscatter signals shows the same swath of the Earth's surface from slightly staggered angles of vision. Once they have been analysed by computer and simultaneously superimposed, reception with a considerably larger antenna can be simulated, thereby producing an artificial increase in aperture size. This gives the ERS-1 antenna, measuring ten metres in length, the same resolution as an antenna with an 800-metre diameter and in "image mode" it produces radar pictures of the surface of the Earth or its oceans with a pixel size corresponding to an area of only 30 m x 30 m.

However, the SAR cannot clearly identify an oil slick in every case. Even a clean sea surface shows up as a dark patch on a SAR image when wind speed does not exceed 3 m/s (corresponding to a wind force of about 2). In such cases, sea surface roughness caused by what is only light breeze is not sufficient to produce a discernable impact on the backscatter from the radar beam. On the other hand, the smoothing effect of at least thin oil slicks at wind speed above 10 m/s (corresponding to a wind force of 6) is not sufficient to produce a recognisable difference in surface roughness and consequently in sea surface backscatter response.

During the ERS trial phase, 20 tonnes of crude oil were poured under supervision into the sea in the Haltenbanken region of Norway in order to demonstrate how oil spills are detected, acquire experience and take calibration measurements. The oil slick was then removed. The results of this operation have since proved valuable for detecting and pinpointing countless incidents of oil pollution in the Earth's oceans.

One of ERS-1's most impressive achievement was its demonstration of the superiority of radar observation from space in December 1992 when the Aegean Sea tanker ran aground off the port of La Coruna in northwest Spain, broke up and finally exploded, emptying its entire cargo of about 79 000 tonnes of crude oil into the sea.

It was not until ten days later, when ERS-1 flew over the scene for the first time and observed it using its SAR instrument, that the extant of the oil slick became clearly apparent. Blown by southerly and westerly winds, the oil had already spread over an area several hundred metres square and in addition had penetrated the bay east of La Coruna. In all, a stretch of more than 200 kilometres of coastline was polluted. In mid-December the wind veered southeast to northeast, driving the slick westwards along the coast to the islands of Sisargas.

The next time ERS-1 passed over the area, early in January 1993, the SAR image showed the slick to be breaking up further off the coast and on 17 January, the whole area appeared to be "clean"again. But high waves must have prevented the detection of oil residues because on 8 February, when the sea was calm, remnants with long "trails" were clearly visible, particularly in areas adjoining several bays.

Dr. J. Lichtenegger, who works at ESA's data-processing centre ESRIN (Frascati, Italy) makes the following comment: "The ERS-1 observations over this period showed that SAR data can be a valuable tool for the detection and monitoring of oil slicks, not only because they can be gathered regardless of cloud cover but also, and above all, because they can be made available so quickly." The mass of data produced by SAR is enormous -- up to 120 megabits a second (equivalent to 5600 pages of text). As the data cannot be stored on board the satellite, they have to be transmitted in real time to a ground station in the satellite's direct line of sight. For this purpose, ESA operates four ERS stations in Europe and Canada, which are supplemented by twenty or so national stations spread across the world. The "express processing" of raw data to produce usable numerical data and images means that only a few hours after reception at the Kiruna (Sweden) or Fucino (Italy) station, the relevant information can be passed on to users in Europe and elsewhere.

However, notwithstanding spectacular tanker accidents, which never fail to capture the attention of the media, a much bigger cause of ocean pollution is the deliberate policy of secretly tipping oil residues into the sea. This urgently calls for monitoring of the high seas, which cannot be done as part of the routine inspections carried out by national coastguard partols. Here too, trial observations using ERS-1 have shown that, in the Mediterranean for instance, such illegal practices can swiftly be detected and the offenders identified beyond all doubt provided satellite overpass follow in quick enough succession.

When the satellite passes over the Earth's extreme northern and southern areas, this time requirement is in any event guaranteed. Since the ERS-1's orbit lies, more or less over the poles, there is a big overlap of the areas covered on each overpass, with the result that the satellite can collect data more frequently than it can in an area close to the equator. For some years, Norway has been taking advantage of this orbit and using ERS data to monitor its coastal zones. Furthermore, it has set up its own receiving station in Tromso which is jointly operated by the SFT--the Norwegian environmental monitoring office--some oil companies and a firm specialising in oil-pollution control, and is supplied with ERS-1 data by ESA. Data are recorded and pre- processed before being forwarded to a data-processing centre for which Norwegian defence ministry is responsible. From there they are sent directly to the environmental monitoring office. Other countries want to follow suit and the Netherlands has already completed a successful pilot phase.

MOVIE "CONGO" DRAWS ON SPACE RADAR STUDIES OF CENTRAL AFRICA
NASA press release

"Congo," the most popular movie in America this week, depicts futuristic remote-sensing technology and satellite communication.

In real-life, scientists at NASA's Jet Propulsion Laboratory have used imaging radar flying aboard the space shuttle to study the habitat of the mountain gorillas of Central Africa--the same area where "Congo" takes place.

"The Virunga volcano chain in Rwanda, the area that's also depicted in the film, is ideally suited for study by radar because the mountains are perennially covered by clouds and the radar is able to see through clouds," said Dr. Diane Evans, the radar project scientist at JPL.

The data were taken by the Spaceborne Imaging Radar C/X-band Synthetic Aperture Radar (SIR-C/X-SAR), part of NASA's Space Radar Laboratory which flew onboard the space shuttle Endeavour in April and October 1994.

"We had actually targeted this area for study because it's also an active volcano area--another point which is made in the movie--and we are involved in studying several volcanoes around the world that are potential threats to the local populations," Evans said.

Evans and her team have provided the radar data to scientists at the Dian Fossey Gorilla Fund in London and Rutgers University in New Jersey. Those researchers have constructed a map of the gorilla habitat using the JPL radar data and provided the map to the producers of "Congo" for use in the movie.

"When the book 'Congo' was written in the early 1980s, the technology seemed very futuristic, but here we are in 1995 and this technology has become a reality," Evans said.

The study of the gorilla habitat is just one of several experiments conducted by SIR-C/X-SAR. Scientists are continuing to analyze data from several hundred sites around the globe which they hope will aid them in their studies of Earth's changing environment.

SIR-C/X-SAR is a joint mission of NASA and the German and Italian space agencies. JPL manages the SIR-C portion of the mission for NASA's Office of Mission to Planet Earth.

End *Marsbugs* Vol. 2, No. 9